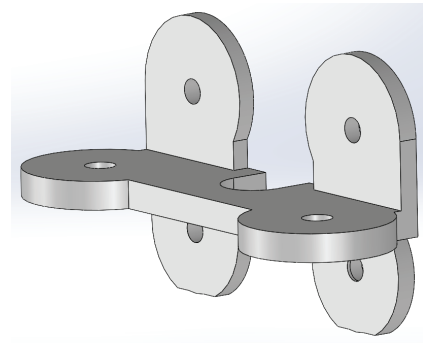
DESIGN CHALLENGE

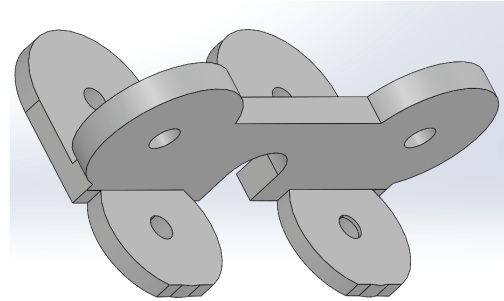
Topology Optimization of ULA bracket

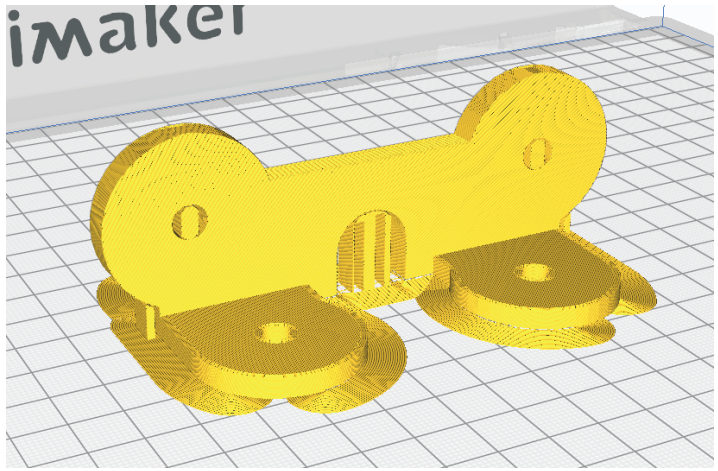
INTUITIVE DESIGN

The initial bracket design as provided in the contest weighed 0.97 lbs when manufactured with Ultem 9085 as described in the problem brief. Apart from being over the weight limit compliancy required by the challenge, the bracket was grossly overdesigned and had too much material outward from the area of application of force and bolting region. Redesigning was done on Solidworks 2020.

In the Intuitive (re)design of the bracket, all the material outward of this general area was removed. Following the edge constraints as given in the challenge, revolute geometries around the bolt holes were constructed to keep the edges at a distane of twice the hole diameter. Following this, the load bearing area was kept at largest area possible to keep the force uniformly distributed. The region beneath the load bearing area was removed such that the bolt hole - edge constraints were still satisfied. This was done to make the entire part comply with the weight restrictions. The walls of the geometry were **not** extended to exploit the 0.04 in thickness allowance in interest of more structural stability and the fact that the weight requirements were found to be compliant without the additional effort. The weight of the intuitively redesigned part was found to be at 0.09 lbs as reported by the mass properties in Solidworks.







MANUFACTURABILITY ANALYSIS - INTUITIVE DESIGN

The manufacturability analysis of the intuitive part was done on Ultimaker Cura 4.8.0 , with Ultimaker S5 as the printer. The part was simulated to be built at an infill of 20% and a profile of 0.15 mm. The material used was again Ultem 9085. The print simulation was done in XY orientation, with quadra-holed side as base.

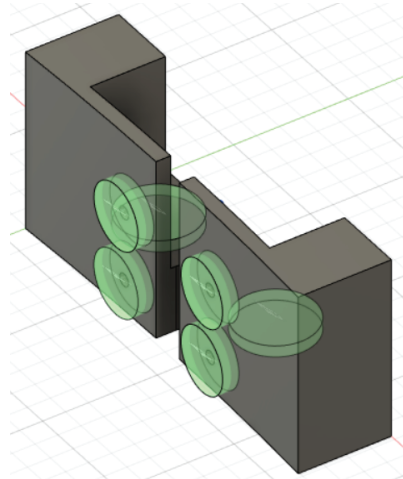
The analysis showed that the required time to build such a part along with support structures would be about 27 grams and would require about 3 hours and 25 mins to print.

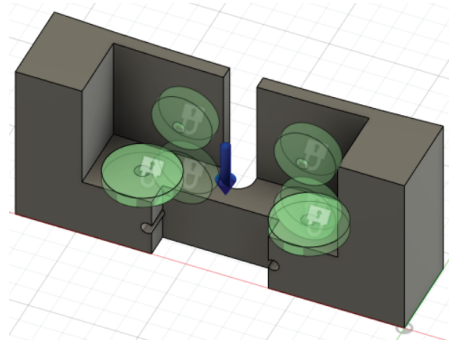
TOP-OPT DESIGN AND MANUFACTURABILITY ANALYSIS

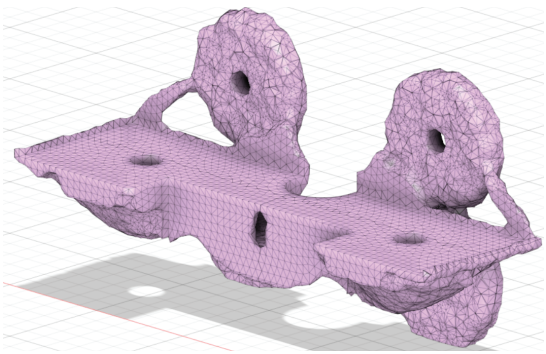
Topology optimzation was one on Fusion 360 using the 'Shape Optimization' Simulation Module. The original part was imported to the software and the six bolt holes were given 'Fixed Structural Constraints'. The constraints were applied at the back side (i.e. interfacing end) on the holting bolt holes and the up side (i.e. the load platform side) of the load bolt holes. The required load of 600 lbf was applied on the load platform. Material properties of Ultem 9085 were applied to the model.

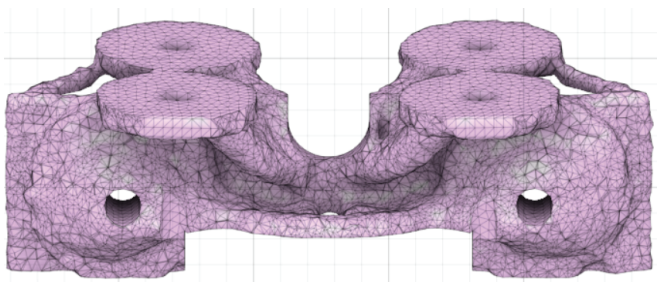
The preservation region was decided to be cylinders of about 5 mm thickness and 5 times the hole radius (as prescribed). These were located concentrically with the holes and were located as shown in adjoining images. A symmetric plane was used in earlier iterations but was then **removed** due to discontinous appendages as result. The topology optimization was done at the finest mesh setting and with a target of **10.25 % mass** as that would hit the target mass requirement of 0.1 lbs.

The build simulation for the topology optimized design was done using the same settings as the intuitive design. The manufacturability analysis of the design revealed that the designed part would require about 5 hours and 51 mins to print while consuming about 35 grams of material.









COMPARISONS BETWEEN THE RESULTS

Inline with expectations to some degree, the comparision of the manufacturing analysis of both the designs reveals that the topology optimized design takes more time and material as compared to the intuitive design. This can be attributed to the fact that the optimized design was obtained as a result continuos simulations to yield the most structurally integral design that was compliant to requirements which in turn resulted in a really complex geometry.

Advantages of Topology Optimized Design over Intuitive Design

The TopOpt design turns out to be functionally better than the intuitive design as it has better structural intergrity.

The TopOpt design handles edges and corners in a much sensible and efficient way with keeping only what's necessary.

Disadvantages of Topology Optimized Design over Intuitive Design

The TopOpt design consumes more material than the Intuitive design.

The TopOpt design is also difficult to manufacture as it has a lot of complex geometries and support material due to more overhangs as compared to the Intuitive design.

The awkward positioning of support material also makes the post-processing difficult.